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APPLICATION NUMBER: 60/463,763

FILING DATE: April 18, 2003

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PTO/SB/16 (8-00)

Approved for use through 10/31/2002. OMB 0651-0032

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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

INVENTOR(S)					
Given Name (first and middle (if any))		Family Name or Surname		Residence (City and either State or Foreign Country)	
Eduardo		Diaz Del Rio Perez		Madrid, Spain	
<input type="checkbox"/> Additional inventors are being named on the _____ separately numbered sheets attached hereto					
TITLE OF THE INVENTION (280 characters max)					
Explosion-Inhibiting Article of Manufacture					
Direct all correspondence to: CORRESPONDENCE ADDRESS					
<input checked="" type="checkbox"/> Customer Number		35172		 Patent Customer Number Bar 35172 PATENT TRADEMARK OFFICE	
OR Type Customer Number here					
<input type="checkbox"/> Firm or Individual Name		David M. McConoughey			
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ENCLOSED APPLICATION PARTS (check all that apply)					
<input checked="" type="checkbox"/> Specification Number of Pages		14 + 15 Claims		<input type="checkbox"/> CD(s), Number	
<input checked="" type="checkbox"/> Drawing(s) Number of Sheets		7		<input type="checkbox"/> Other (specify)	
<input type="checkbox"/> Application Data Sheet. See 37 CFR 1.76					
METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT (check one)					
<input checked="" type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27.				FILING FEE AMOUNT (\$)	
<input checked="" type="checkbox"/> A check or money order is enclosed to cover the filing fees #121				\$80.00	
<input type="checkbox"/> The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number					
<input type="checkbox"/> Payment by credit card. Form PTO-2038 is attached.					
The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.					
<input checked="" type="checkbox"/> No.					
<input type="checkbox"/> Yes, the name of the U.S. Government agency and the Government contract number are:					

Respectfully submitted,

SIGNATURE

TYPED or PRINTED NAME

TELEPHONE

David M. McConoughey

212.268.1530

Date

04/18/2003

REGISTRATION NO.

(if appropriate)

Docket Number:

24786

576391-2001

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

This collection of information is required by 37 CFR 1.51. The information is used by the public to file (and by the PTO to process) a provisional application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the complete provisional application to the PTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, Washington, D.C. 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Box Provisional Application, Assistant Commissioner for Patents, Washington, D.C.

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Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE**FEE TRANSMITTAL
for FY 2003**

Effective 01/01/2003. Patent fees are subject to annual revision.

☒ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT (\$) \$80.00

Complete if Known

Application Number	
Filing Date	
First Named Inventor	Eduardo Diaz Del Rio Perez
Examiner Name	
Group Art Unit	
Attorney Docket No.	576391-2001

METHOD OF PAYMENT (check all that apply)☒ Check ☐ Credit card ☐ Money Order ☐ Other ☐ None☐ Deposit Account # 121

Deposit Account Number	
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☐ Charge fee(s) indicated below, except for the filing fee to the above-identified deposit account.
FEE CALCULATION**1. BASIC FILING FEE**

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description	Fee Paid
1001 750	2001 375	Utility filing fee	
1002 330	2002 165	Design filing	
1003 520	2003 260	Plant filing fee	
1004 750	2004 375	Reissue filing	
1005 160	2005 80	Provisional filing fee	80.00
SUBTOTAL (1)			(\$)

2. EXTRA CLAIM FEES FOR UTILITY AND

Total Claims	Extra Claims	Fee from below	Fee Paid
Independent Claims	-20** = 0	X	0.00
Multiple Dependent	-3** = 0	X	0.00

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description	Fee Paid
1202 18	2202 9	Claims in excess of 20	
1201 84	2201 42	Independent claims in excess of 3	
1203 280	2203 140	Multiple dependent claim, if not paid	
1204 84	2204 42	** Reissue independent claims over original patent	
1205 18	2205 9	** Reissue claims in excess of 20 and over original patent	
SUBTOTAL (2)			(\$)

**or number previously paid, if greater; For Reissues, see above

FEE CALCULATION (continued)**3. ADDITIONAL FEES**

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description	Fee Paid
1051 130	2051 65	Surcharge - late filing fee or oath	
1052 50	2052 25	Surcharge - late provisional filing fee or cover sheet	
1053 130	1053 130	Non - English specification	
1812 2,520	1812 2,520	For filing a request for ex parte reexamination	
1804 920*	1804 920*	Requesting publication of SIR prior to Examiner action	
1805 1,840*	1805 1,840*	Requesting publication of SIR after Examiner action	
1251 110	2251 55	Extension for reply within first month	
1252 410	2252 205	Extension for reply within second month	
1253 930	2253 465	Extension for reply within third month	
1254 1,450	2254 725	Extension for reply within fourth month	
1255 1,970	2255 985	Extension for reply within fifth month	
1401 320	2401 160	Notice of Appeal	
1402 320	2402 160	Filing a brief in support of an appeal	
1403 280	2403 140	Request for oral hearing	
1451 1,510	1451 1,510	Petition to Institute a public use proceeding	
1452 110	2452 55	Petition to revive - unavoidable	
1453 1,300	2453 650	Petition to revive - unintentional	
1501 1,300	2501 650	Utility issue fee (or reissue)	
1502 470	2502 235	Design issue fee	
1503 630	2503 315	Plant issue fee	
1460 130	1460 130	Petitions to the Commissioner	
1807 50	1807 50	Processing fee under 37 CFR § 1.17(q)	
1806 180	1806 180	Submission of Information Disclosure Statement	
8021 40	8021 40	Recording each patent assignment per property (times number of properties)	
1809 750	2809 375	Filing a submission after final rejection (37 CFR § 1.129(a))	
1810 750	2810 375	For each additional invention to be examined (37 CFR § 1.129(b))	
1801 750	2801 375	Request for Continued Examination (RCE)	
1802 900	1802 900	Request for expedited examination of a design application	

Other fee (specify)

*Reduced by Basic Filing Fee Paid

SUBTOTAL (3)

(\$)

SUBMITTED BY

Name (Print/Type)	David M. McConoughey	Registration No. (Attorney/Agent)	24786	Complete (if applicable)	
Signature	<i>David M. McConoughey</i>	Telephone	212.268.1530	Date	April 18, 2003

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THE UNITED STATES PATENT AND TRADEMARK OFFICE

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CITIZENSHIP: **SPAIN**
TITLE OF THE INVENTION: **EXPLOSION-INHIBITING ARTICLES OF**
MANUFACTURE
SPECIFICATION: **14 PAGES**
DRAWINGS: **7 SHEETS (FIGS. 1-16)**
CLAIMS: **15 CLAIMS (6 INDEPENDENT)**
ABSTRACT OF THE DISCLOSURE: **1 PAGE**
ATTORNEY'S DOCKET NO.: **576391-2001**

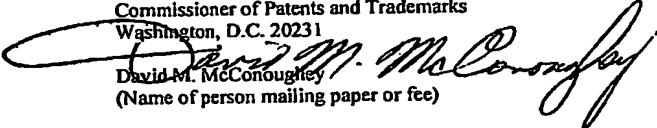
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PROVISIONAL
PATENT APPLICATION

TITLE OF THE INVENTION

Explosion-inhibiting Articles of Manufacture.

CROSS-REFERENCES TO RELATED APPLICATIONS

Not applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable.

FIELD OF THE INVENTION

The present invention relates to articles of manufacture for inhibiting the explosion of flammable fluids contained in closed containment vessels and, in particular, for inhibiting boiling liquid, expanding vapor explosions.

BACKGROUND OF THE INVENTION

Previous approaches to inhibiting the explosion of flammable liquid vapors, especially to inhibiting boiling liquid expanding vapor explosions, have failed to take into account the settlement and the compaction of explosion mitigation devices during the service of those devices.

SUMMARY OF THE INVENTION

The present invention comprises an article of manufacture comprising an apertured sheet material, the sheet material being provided with at least one row of a plurality of polygonal

1 apertures, at least one of said polygonal apertures being irregular with respect to at least one
2 adjacent polygonal aperture, and having physical characteristics comprising
3 i. a surface area per unit volume of application of at least about 2,000 times the contact
4 surface of flammable fluids contained in a containing vessel,
5 ii. a heat conductivity of at least about 0.025 Cal/cm-sec.

6 Preferably, the inner peripheral length of at least one of the apertures is unequal to the inner
7 peripheral length of at least one adjacent aperture. Further, the article preferably has a
8 compressive yield of not more than about 10 percent.

9 In another embodiment, the foregoing sheet material is in the form of a cylindrical roll or
10 bale

11 In a further embodiment, the foregoing sheet material is in the form of a spheroid
12

13 BRIEF DESCRIPTION OF THE DRAWINGS

14 Figure 1 is a top plan view of a sheet material for use in the present invention.

15 Figure 2 is a side elevation view taken in transverse section along lines 2-2 in Figure 1 of
16 a sheet material for use in the present invention.

17 Figure 3 is a top plan view of an apertured sheet material for use in the present invention.

18 Figure 4 is a side elevation view taken in transverse section along lines 4-4 in Figure 3 of
19 an apertured sheet material for use in the present invention.

20 Figure 5 is a side elevation view taken in longitudinal section along lines 5-5 in Figure 3
21 of an apertured sheet material for use in the present invention.

22 Figure 6 is a top plan view of an expanded, apertured sheet material for use in the present
23 invention.

1 Figure 7 is a side elevation view taken in transverse section along lines 7-7 in Figure 6 of
2 an expanded, apertured sheet material for use in the present invention.

3 Figure 8 is a top plan view on an enlarged scale of portion of Figure 7 of an expanded,
4 apertured sheet material for use in the present invention.

5 Figure 9 is a side elevation view taken in transverse section along lines 9-9 in Figure 8 of
6 an expanded, apertured sheet material for use in the present invention.

7 Figure 10 is a top plan view of a waved, expanded, apertured sheet material for use in the
8 present invention.

9 Figure 11 is a side elevation view taken in transverse section along lines 11-11 in Figure
10 10 of a waved, expanded, apertured sheet material for use in the present invention.

11 Figure 12 is a side elevation view taken in longitudinal section along lines 12-12 in
12 Figure 10 of a waved, expanded, apertured sheet material for use in the present invention.

13 Figure 13 is a front perspective view of a cylindrical shape made in accordance with the
14 present invention.

15 Figure 14 is a front elevation view of a cylindrical shape made in accordance with the
16 present invention.

17 Figure 15 is a top plan view taken in horizontal section along lines 15-15 in Figure 14 of
18 a cylindrical shape made in accordance with the present invention.

19 Figure 16 is a side elevation view of a spheroidal shape made in accordance with the
20 present invention.

21

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention comprises, as an article of manufacture, an apertured sheet material, the sheet material being provided with at least one row of a plurality of polygonal apertures, at least one of said polygonal apertures being irregular with respect to at least one adjacent polygonal aperture, and having physical characteristics comprising

- i. a surface area per unit volume of application of at least about 2,000 times the contact surface of flammable fluids contained in a containing vessel,
- ii. a heat conductivity of at least about 0.025 Cal/cm-sec.

Preferably, the inner peripheral length of at least one of the apertures is unequal to the inner peripheral length of at least one adjacent aperture. Further, the article preferably has a compressive yield of not more than about 10 percent.

In this way, an apertured sheet material is provided that produces a configuration that is resistant to settling and to compaction. Such an article of manufacture is helpful in inhibiting a flammable fluid explosion in a closed containment vessel containing flammable fluid, particularly in inhibiting a boiling liquid, expanding vapor explosion (or "BLEVE".)

A sheet material for use in the present invention, and as illustrated in Figs. 1 & 2 by way of example, comprises a sheet of heat-conductive material, preferably having the aforesaid physical properties. The sheet has a flat, generally planar configuration with a thickness from about 0.01 mm (1 micron) to about 0.1 mm (10 microns), desirably from about 0.03 mm (3 microns) to about 0.07 mm (7 microns) and preferably from about 0.04 mm (4 microns) to about 0.05 mm (5 microns).

The sheet material desirably has good heat conductivity in order to adequately dissipate heat in inhibiting the explosion of flammable fluids contained in closed containers, particularly

1 for inhibiting BLEVEs. The heat conductivity should be at least about 0.025 Cal/cm-sec,
2 particularly for materials with a specific density of from about 2.8 g/cm³ to about 19.5 g/cm³,
3 and preferably from about 0.025 to about 0.95 Cal/cm-sec, particularly for materials with a
4 specific density of from about 2.8 g/cm³ to about 19.5 g/cm³

5 The heat conductivity is nominally about 2.36 Watt/cm-deg (Kelvin) at 273 T.K. (degrees
6 Kelvin) (for Aluminum)-The following can be used as candidate alloy or raw materials
7 depending on the application:

8 Silver 4.28 Watt/cm-deg (Kelvin) at 273 T.K.,
9 Gold 3.2018 Watt/cm-deg (Kelvin) at 273 T.K.,
10 Copper 4.1 Watt/cm-deg (Kelvin) at 273 T.K.,
11 Stainless Steel 0.835 Watt/cm-deg (Kelvin) at 273 T.K., and
12 polymeric material

13 for a material with a density, for example, of 2.7 g/cm³ (Al); 10.5 g/cm³ (Silver), 19.3 g/cm³
14 (Gold), 8.92 g/cm³ (Copper), 7.86 g/cm³ (Stainless Steel) or 0.9 to 1.5 g/cm³ (polymeric
15 material.

16 The sheet material is desirably relatively chemically inert to the contents of the closed
17 container for the service life of the container and/or the residence period of the contents in the
18 container. Materials may be metals and metallic alloys, such as aluminum, magnesium, copper,
19 gold, silver or stainless steel, or nonmetallics, such as polymeric or plastic materials.

20 A slit sheet material for use in the present invention, and as is illustrated in Figs. 3, 4 & 5
21 by way of example, comprises a sheet material 10 having a plurality of parallel lines P (Fig. 3) of
22 elongated rectangular apertures 12, preferably slots. Each rectangular aperture 12, and each line
23 P of rectangular apertures 12, extends parallel to the longitudinal central axis of the sheet. Each

1 rectangular aperture 12 in a line P of rectangular apertures 12 is spaced from the rectangular
2 aperture 12 preceding it and the rectangular aperture 12 following it by an intermediate web 14
3 of solid, imperforate sheet material. In other words, in proceeding longitudinally along a line P of
4 rectangular apertures 12, there is a rectangular aperture 12 followed by an intermediate web 14,
5 followed by a rectangular aperture 12 followed by an intermediate web 14, et cetera.

6 In forming a sheet with polygonal apertures, the intermediate webs 14 of adjacent lines of
7 rectangular apertures are offset with respect to each other so that in proceeding transversely
8 across the sheet along a line T that is perpendicular to the longitudinal central axis of the sheet
9 and that passes through an intermediate web 14 of an adjacent longitudinal line P of rectangular
10 apertures 12,

11 a. the transverse line T will pass across a rectangular aperture 12 of the next adjacent
12 longitudinal line P of rectangular apertures 12,

13 b. then through an intermediate web 14 of the next adjacent longitudinal line P of
14 rectangular apertures 12,

15 c. then across a rectangular aperture 12 of the next adjacent longitudinal line of rectangular
16 apertures, et cetera.

17 In this way, the longitudinally extending rectangular apertures 12 alternate with
18 intermediate webs 14 transversely across the sheet 10.

19 Preferably, the length of each longitudinally extending rectangular aperture 12 in
20 proceeding along a transverse line T of rectangular apertures 12 should be different from the
21 length of the rectangular aperture 12 preceding it and the length of the rectangular aperture 12
22 following it. In other words, the length of each longitudinally extending rectangular aperture 12
23 is preferably different from the length of the next adjacent longitudinally extending rectangular

1 aperture 12 in a transverse line T across the width of the sheet. Further, with respect to each
2 rectangular aperture 12, the length of each of the four most adjacent rectangular apertures 12 in
3 the two most adjacent longitudinal lines P of rectangular apertures 12 should preferably also be
4 different from that of the rectangular aperture 12.

5 The lengths of the respective longitudinally extending rectangular apertures 12 in a
6 transverse line T across the width of the sheet may be random with respect to each other.
7 Alternatively, the lengths of each respective longitudinally extending rectangular aperture 12
8 may increase progressively in length in a transverse line T across the width of the sheet or
9 decrease in length. In one alternative embodiment, the lengths of each respective longitudinally
10 extending rectangular aperture 12 increase progressively in length in a transverse line T across
11 the width of the sheet and the lengths of each respective longitudinally extending rectangular
12 aperture 12 in the next adjacent transverse line T decreases progressively in length across the
13 width of the sheet.

14 The length of the apertures 12 is nominally from about 10 to about 15 mm., desirably
15 from about 12 mm. to about 15 mm., and preferably, from about 13 mm. to about 15 mm. In this
16 way, an aperture of 10 mm. might be followed by one of 10.033 mm, followed by one of 10.06
17 mm. The width of each rectangular aperture, or slot, may be from about .02 mm. to .06 mm,
18 desirably from about .03 mm. to about .05 mm., and, preferably, from about .04 mm. to about .05
19 mm. The spacing between the rows of apertures may be varied based on the properties of the
20 material used for the sheet.

21 The intermediate web between apertures, in turn, is from about 2.5 mm to about 4.5 mm.
22 In this way, an intermediate web of 3 mm. might be followed by one of 3.5 mm, followed by one
23 of 4 mm.

1 In this way, irregularity is induced in the expanded apertured sheet that produces
2 configurational resistance to settling and compaction.

3 A slit sheet material for use in the present invention, and as illustrated in Figs. 6 through
4 9 by way of example, is converted into an expanded, apertured (or fenestrated) sheet material 20
5 of the present invention that is provided with a plurality of many-sided, or polygonal apertures
6 22, such as, for example and as illustrated, hexagonal apertures. At least one polygonal aperture
7 is irregular with respect to at least one adjacent polygonal aperture.

8 For example, the sum of the lengths of the inner edges of the sides of a polygonal
9 aperture 22, for example lengths 22a, 22b, 22c, 22d, 22e, and 22f in Fig. 9, determine an inner
10 peripheral length of a polygonal aperture 22. The inner peripheral length of each polygonal
11 aperture 22 in proceeding along a transverse line T of polygonal apertures 22 should be different
12 from the inner peripheral length of the polygonal aperture 22 preceding it and the inner
13 peripheral length of the polygonal aperture 22 following it. In other words, the inner peripheral
14 length of each polygonal aperture 22 is different from the inner peripheral length of the next
15 adjacent polygonal aperture 22 in a transverse line across the width of the sheet. Further with
16 respect to each polygonal aperture 22, the inner peripheral length of each of the four most
17 adjacent polygonal apertures 22 in the two most adjacent longitudinal lines of polygonal
18 apertures 22 should preferably also be different from that polygonal aperture 22.

19 The inner peripheral lengths of the respective polygonal apertures 22 in a transverse line
20 T across the width of the sheet may be random with respect to each other. Alternatively, the
21 inner peripheral lengths of each respective polygonal aperture 22 may increase progressively in
22 inner peripheral length in a transverse line T across the width of the sheet or decrease. In one
23 alternative embodiment, the inner peripheral lengths of each respective polygonal aperture 22

1 increase progressively in length in a transverse line T across the width of the sheet and the inner
2 peripheral lengths of each respective polygonal aperture 22 in the next adjacent transverse line T
3 decrease progressively in length across the width of the sheet.

4 The term "irregular" as it is used herein in the context of the inner peripheral length of at
5 least one of said apertures being unequal to the inner peripheral length of at least one adjacent
6 aperture means that the numerical value of the inequality of one inner peripheral length with
7 respect to the other inner peripheral length is greater than the variation in inner peripheral length
8 produce by manufacturing variation or manufacturing tolerance. In other words, the inequality is
9 intentional rather than random or inherent manufacturing variation.

10 While the irregularity of at least one polygonal aperture with respect to at least one
11 adjacent polygonal aperture has been described in terms of the inner peripheral length of at least
12 one of said apertures being unequal to the inner peripheral length of at least one adjacent
13 aperture, it should be understood that irregularity can also be produced in other ways, such as
14 having a different number of sides on the polygon (such as a pentagon or a heptagon versus a
15 hexagon) or the length of a side of a polygonal aperture being different from the corresponding
16 side of an adjacent polygonal aperture (i.e., greater than manufacturing variation or tolerance as
17 previously stated) or the angle between two adjacent sides of a polygonal aperture being different
18 from the corresponding angle between the corresponding two sides of an adjacent polygonal
19 aperture. For example, the respective lengths of the side edges of the apertures may not all be
20 equal, i.e., at least one side may not be the same length as any of the other sides, thereby
21 providing an aperture with a configuration such as an irregular polygon.)

1 In this way, when multiple expanded, apertured sheets are placed on top of each other,
2 they are unable to align polygonal apertures and nest into each other, settling and thereby
3 reducing the effective thickness of the multiple sheets 20.

4 The expanded, apertured (or fenestrated) sheet material 20 of the present invention
5 desirably has a compression yield, or resistance to compaction (i.e., permanent deformation
6 under compressive load), of not more than 10 percent. Ideally, however, there is essentially no
7 compressive yield in service.

8 The expanded, apertured sheet material 20 is formed by tensioning slotted sheet material
9 10 over large wheel of a varying diameter positioned in such a way as to regulate the spreading
10 of the sheet material to an additional width 50% to 100 % that of the raw sheet material width so
11 as to ensure the resulting openings form a plurality of polygonal apertures 22 as aforesaid.

12 The expanded, apertured sheet material 20 desirably has an effective surface area per unit
13 volume from at least about 2,000 times the contact surface of flammable liquid/ vapors and gases
14 contained in closed containers, particularly for inhibiting boiling liquid, expanding vapor
15 explosions, and preferably from at least about 3,000 times the contact surface of flammable
16 liquid/ vapors and gases contained in closed containers. The term "contact surface" refers to the
17 surface area of the containment vessel that is in contact with the gaseous, aerosol or vapor phase
18 of the flammable fluid that is contained in the containment vessel. Normally the flammable
19 fluids (liquid, vapor, aerosol or gas) are in contact with the surface areas of the walls of the
20 container containing the flammable fluid. The insertion of the finished expanded, apertured sheet
21 material increases the surface area of contact with the flammable fluid by at least about 2,000
22 times this contact surface area, preferably at least about 3,000 times this contact surface area.
23 This ratio is significant and to compromise this proportion of contact relative to the specific fluid

1 in question is to risk a BLEVE. This area varies in relation to the heat conductivity and
2 compressive yield strength of the material used.

3 In one embodiment, expanded, apertured sheet material 20 for use in the present
4 invention, and as is illustrated in Fig. 16 by way of example, may be formed into a shape that
5 comprises a body 100 with a generally spheroidal external configuration or shape.

6 The internal configuration of the generally spheroidal body 100 comprises at least one
7 strip of the aforesaid expanded, expanded sheet material that is folded and/or crimped and
8 cupped to form said spheroidal shape. The generally spheroidal shape may be formed using a
9 section of expanded, apertured sheet material of a size proportional to about 20% of the width of
10 the expanded, apertured sheet material.

11 The outer spherical periphery of the spheroid 100 encloses a volume. The surface area of
12 the material contained within this periphery, i.e., inside the spheroid, subject to the application
13 design requirement, is at least about 1.5 square centimeters per cubic centimeter of said volume
14 or larger as required, The surface area of the material should be at least about 2,000 times the
15 contact surface of flammable fluid contained in the enclosing container of those flammable fluid,
16 particularly for inhibiting BLEVEs.

17 The spheroid 100 desirably has a compression yield, or resistance to compaction (i.e.,
18 permanent deformation under compressive load), of not more than 10 percent. Ideally, however,
19 there is essentially no compressive yield in service.

20 The structural strength of the final product can also be modified by using a different heat
21 hardness in the sheet material.

22 In an alternative embodiment of the present invention, expanded, apertured sheet material
23 20 for use in the present invention, and as illustrated in Figs. 10 through 12 by way of example,

1 is provided with a transverse undulating, or sinusoidal, wave 42 formed in it and the waved,
2 expanded, apertured sheet material 40, as illustrated in Figs. 13 through 15 by way of example, is
3 helically wound into a cylindrical shape 200, such as a cylindrical bale. The cylindrical shape
4 200 is generally circular in transverse section (Fig. 14) and generally rectangular in longitudinal
5 section (Fig. 15.) In a further form of this cylindrical embodiment, a flat expanded, apertured
6 sheet material may be wound into the cylindrical form. In a still further form (Figs. 13-15) of this
7 cylindrical embodiment, a sheet of flat expanded, apertured sheet material 202 and a sheet of
8 waved, expanded, apertured sheet material 204 may be wound into the cylindrical form, thereby
9 forming alternate layers of flat and waved expanded, apertured sheet material in the cylindrical
10 shape.

11 Because of the wave 42 formed in the sheet material 40, with the sheet material 40
12 helically wound, the wave 42 causes an increase in the effective diameter of the cylinder 200. In
13 this way, the effective surface area contained within a given outer periphery of the cylinder 200
14 is increased. This provides large included volume cylinders 200 with low mass and high internal
15 effective area.

16 The cylinder 200 desirably has a compression yield, or resistance to compaction (i.e.,
17 permanent deformation under compressive load), of not more than 10 percent. Ideally, however,
18 there is essentially no compressive yield in service.

19 The imperforate starting sheet material 1 may be supplied as a continuous, non-perforated
20 web of sheet material. Then, rectangular apertures 12, or slots, are formed in the continuous web
21 in the aforesaid configuration, such as by slitting. Then, the slotted web 10 may be expanded
22 transversely by tensioning the sheet material 10 transversely, such as over a wheel positioned in
23 such a way as to regulate the spreading of the sheet material to an additional width 50% to 100 %

1 that of the raw sheet material width so as to ensure the resulting openings form a plurality of
2 polygonal apertures 22 of irregularity as aforesaid. Adjusting the position and tension of the
3 expanding wheel on the production machine does this. By doing this, the result is the ability to
4 have the walls of the finished honeycomb pattern more or less more erect, thereby increasing the
5 compressive strength of the finished expanded, apertured sheet material 20.

6 Optionally, the expanded, apertured web 20 may have a sinusoidal transverse wave 42
7 formed in it. The form of the wave 42 is introduced or impressed into the lengths of the sheet
8 material 20 as a series of transverse kinks or waves 42 along the length of the web that looks like
9 waves when the finished product is spooled.

10 Cylindrical shapes 200 may be formed by winding the aforesaid expanded, apertured
11 sheet material.

12 Spheroid shapes 100 may be made by feeding the sheet material 20 provided with a
13 plurality of rows of a plurality of parallel apertures 22, the longitudinal central of each being
14 parallel to the longitudinal central axis of the sheet, into a machine using a mechanical device
15 comprising two semi-circular rimmed sections with the working sections opposing each other.
16 One is a stationary semi circular die of a variable radius with a concave working edge. The other
17 is a rotating 360 degree circular die with a concave working edge with a friction surface. The
18 rotation of the circular die against the fixed die forms the sheet material into a tube shape. As the
19 sheet material is drawn through the aperture formed by the interfacing of the circular die rotating
20 against the fixed die, the rotating die grabs a length of sheet material, determined by the material
21 volume required for the diameters of the two semi-circular rimmed sections of the dies. and
22 tumbles the expanded sheet material into a generally spheroidal shape.

1 The expanded, apertured sheet material of the present invention may be used in the following
2 applications:

- 3 1. Cylinders of expanded, apertured sheet material (netting) loaded into large closed vessels,
4 tanks, cans, drums, bulk carriers, fuel tanks of all description, pipe lines, piping, tubing,
5 construction, insulation and in other applications where flammable fluids, such as,
6 flammable liquids, vapors, aerosols or gases are used, stored, or transported;
- 7 2. Spheroids of expanded, apertured sheet material loaded as spheroids into small closed
8 vessels, gas cylinders, gas bottles, fuel tanks of all description, bulk carriers, construction,
9 insulation and in other applications where flammable fluids, such as flammable liquids,
10 vapors, aerosols or gases are, used, stored or transported;
- 11 3. Solar panels; 4. Insulation; 5. Construction material; 6. Sound proofing; 7. Cooling
12 elements for computer equipment; 8. Filters; 9. Heat Exchangers; 10. Fire-proof cloth; 11.
13 Fire-retardants; 12. Aircraft; 13. Refineries; 14. Pipelines; 15. Gasoline stations; 16. Gas
14 tanks and gas cylinders; 17. Gas vehicles; and 18. Bulk fluid carriers and vessels.

CLAIMS

I claim:

1. An explosion-inhibiting article of manufacture comprising an apertured sheet material, said sheet material

a. being provided with at least one row of a plurality of polygonal apertures, at least one of said polygonal apertures being irregular with respect to at least one adjacent polygonal aperture,

and

b. having physical characteristics comprising

i. a surface area per unit volume of application of at least about 2,000 times the contact

surface of flammable fluids contained in a containing vessel, and

ii. a heat conductivity of at least about 0.025 Cal/cm-sec.

2. An explosion-inhibiting article of manufacture in accordance with claim 1, wherein the inner peripheral length of at least one of said apertures is unequal to the inner peripheral length of at least one adjacent aperture.

3. An explosion-inhibiting article of manufacture in accordance with claim 1, wherein the material has a density from about 2.8 g/cm^3 to about 19.5 g/cm^3 .

4. An explosion-inhibiting article of manufacture in accordance with claim 1, wherein said article has a compressive yield of not more than about 10 percent.

5. An explosion-inhibiting article of manufacture having a generally spheroidal shape and comprising an apertured sheet material, said sheet material

- 1 a. being provided with at least one row of a plurality of polygonal apertures, at least one of
- 2 said polygonal apertures being irregular with respect to at least one adjacent
- 3 polygonal aperture,
- 4 and
- 5 b. having physical characteristics comprising
- 6 i. a surface area per unit volume of application of at least about 2,000 times the contact
- 7 surface of flammable fluids contained in a containing vessel, and
- 8 ii. a heat conductivity of at least about 0.025 Cal/cm-sec.
- 9 6. An explosion-inhibiting article of manufacture in accordance with claim 5, wherein the inner
- 10 peripheral length of at least one of said apertures is unequal to the inner peripheral length of at
- 11 least one adjacent aperture.
- 12 7. An explosion-inhibiting article of manufacture in accordance with claim 5, wherein the
- 13 material has a density from about 2.8 g/cm³ to about 19.5 g/cm³.
- 14 8. An explosion-inhibiting article of manufacture in accordance with claim 5, wherein said
- 15 article has a compressive yield of not more than about 10 percent.
- 16 9. An explosion-inhibiting article of manufacture having a generally cylindrical shape and
- 17 comprising an apertured sheet material, said sheet material
- 18 a. being provided with at least one row of a plurality of polygonal apertures, at least one of
- 19 said polygonal apertures being irregular with respect to at least one adjacent
- 20 polygonal aperture,
- 21 and
- 22 b. having physical characteristics comprising

1 i. a surface area per unit volume of application of at least about 2,000 times the contact

2 surface of flammable fluids contained in a containing vessel, and

3 ii. a heat conductivity of at least about 0.025 Cal/cm-sec.

4 · 10. An explosion-inhibiting article of manufacture in accordance with claim 9, wherein the inner

5 peripheral length of at least one of said apertures is unequal to the inner peripheral length of at

6 least one adjacent aperture.

7 11. An explosion-inhibiting article of manufacture in accordance with claim 9, wherein the

8 material has a density from about 2.8 g/cm³ to about 19.5 g/cm³.

9 12. An explosion-inhibiting article of manufacture in accordance with claim 9, wherein said

10 article has a compressive yield of not more than about 10 percent.

11 13. An explosion-inhibiting article of manufacture comprising an apertured sheet material, said

12 sheet material

13 a. being provided with at least one row of a plurality of polygonal apertures,

14 and

15 **b. having physical characteristics comprising**

16 i. a surface area per unit volume of application of at least about 2,000 times the contact

17 surface of flammable fluids contained in a containing vessel, and

18 ii. a heat conductivity of at least about 0.025 Cal/cm-sec,

19 said article having a compressive yield of not more than about 10 percent.

20 14. An explosion-inhibiting article of manufacture having a generally spheroidal shape and

21 comprising an apertured sheet material, said sheet material

22 a. being provided with at least one row of a plurality of polygonal apertures,

23 and

- 1 b. having physical characteristics comprising
- 2 i. a surface area per unit volume of application of at least about 2,000 times the contact
- 3 surface of flammable fluids contained in a containing vessel, and
- 4 ii. a heat conductivity of at least about 0.025 Cal/cm-sec,
- 5 said article having a compressive yield of not more than about 10 percent.
- 6 15. An explosion-inhibiting article of manufacture having a generally cylindrical shape and
- 7 comprising an apertured sheet material, said sheet material
- 8 a. being provided with at least one row of a plurality of polygonal apertures,
- 9 and
- 10 b. having physical characteristics comprising
- 11 i. a surface area per unit volume of application of at least about 2,000 times the contact
- 12 surface of flammable fluids contained in a containing vessel, and
- 13 ii. a heat conductivity of at least about 0.025 Cal/cm-sec,
- 14 said article having a compressive yield of not more than about 10 percent.
- 15

ABSTRACT OF THE DISCLOSURE

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Articles of manufacture formed of an apertured sheet material, the sheet material being provided with at least one row of a plurality of polygonal apertures, at least one of said polygonal apertures being irregular with respect to at least one adjacent polygonal aperture, and having physical characteristics comprising

- i. a surface area per unit volume of application of at least about 2,000 times the contact surface of flammable fluids contained in a containing vessel,
- ii. a heat conductivity of at least about 0.025 Cal/cm-sec.

Preferably, the inner peripheral length of at least one of said apertures is unequal to the inner peripheral length of at least one adjacent aperture. Further, the article preferably has a compressive yield of not more than about 10 percent.

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PTO/SB/81 (02-01)

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First Named Inventor

Eduardo Diaz Del Rio Perez

Group Art Unit

Examiner Name

Attorney Docket Number

576391-2001

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I am the:

☒ Applicant/Inventor.☐ Assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96).**SIGNATURE of Applicant or Assignee of Record**

Name

Eduardo Diaz Del Rio Perez

Signature

Date

April 18, 2003

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple

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(37 CFR 1.63)**

☒ Declaration Submitted with Initial Filing OR ☐ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16(e)))

Attorney Docket Number 576391-2001

First Named Inventor Eduardo Diaz Del Rio Perez

COMPLETE IF KNOWN

Application Number /

Filing Date

Art Unit

Examiner Name

As a below named inventor, I hereby declare that:

My residence, mailing address, and citizenship are as stated below next to my name.

I believe I am the original and first inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Explosion-Inhibiting Articles of Manufacture

the specification of which

(Title of the Invention)

☒ Is attached hereto

OR

☐ was filed on (MM/DD/YYYY)

as United States Application Number or PCT International

Application Number

and was amended on (MM/DD/YYYY)

(if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above:

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I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or (f), or 365(b) of any foreign application(s) for patent, inventor's or plant breeder's rights certificate(s), or 365 (a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent, inventor's or plant breeder's rights certificate(s), or any PCT international application having a filing date before that of the application on which priority is claimed.

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NAME OF SOLE OR FIRST INVENTOR :

☐ A petition has been filed for this unsigned inventorGiven Name
(first and middle [if any]) EduardoFamily Name
or Surname Diaz Del Rio PerezInventor's
Signature

Date April 18, 2003

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☐ A petition has been filed for this unsigned inventorGiven Name
(first and middle [if any])Family Name
or SurnameInventor's
Signature

Date

Residence: City

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☐ Additional inventors are being named on _____ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto.

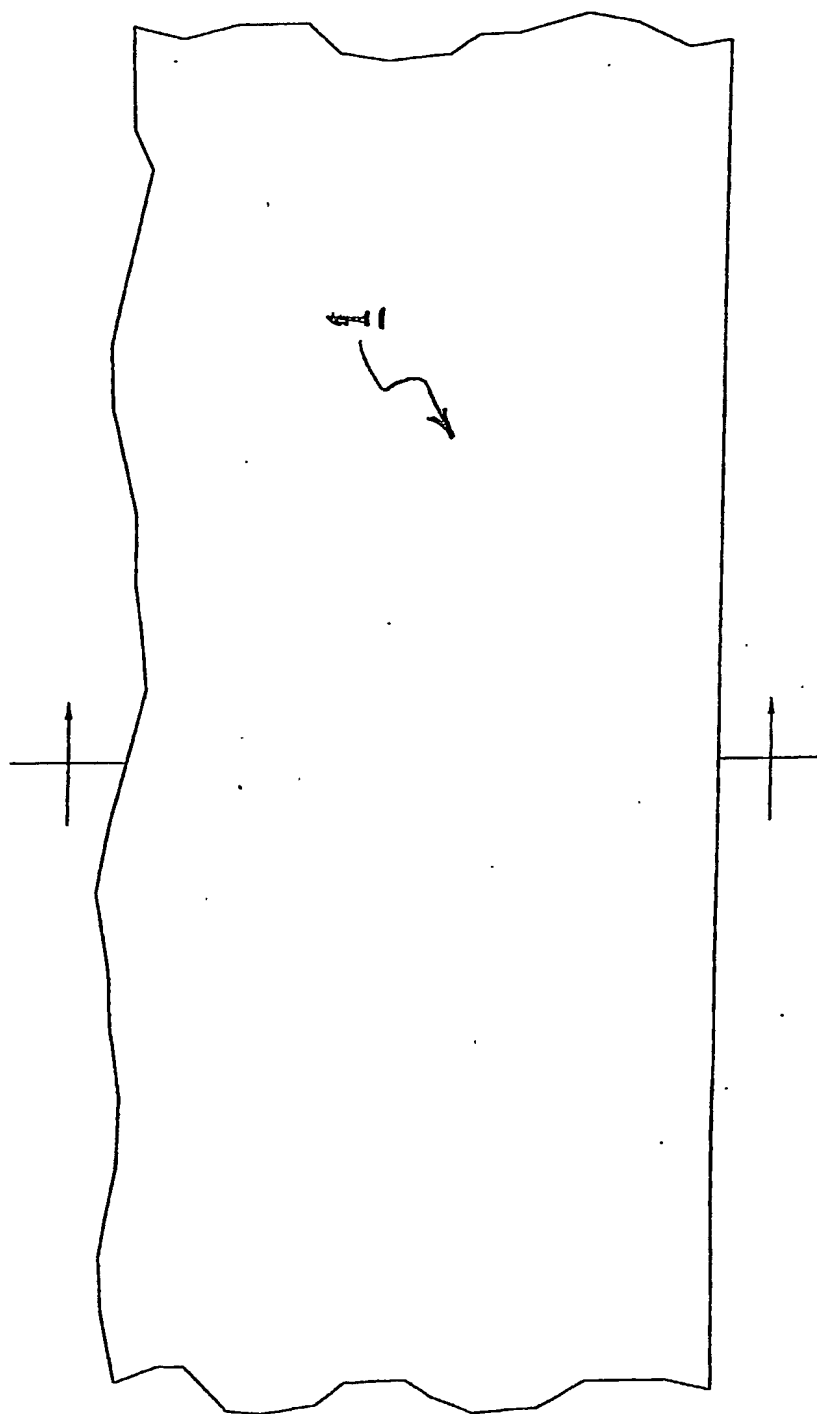


FIG. 1



FIG. 2

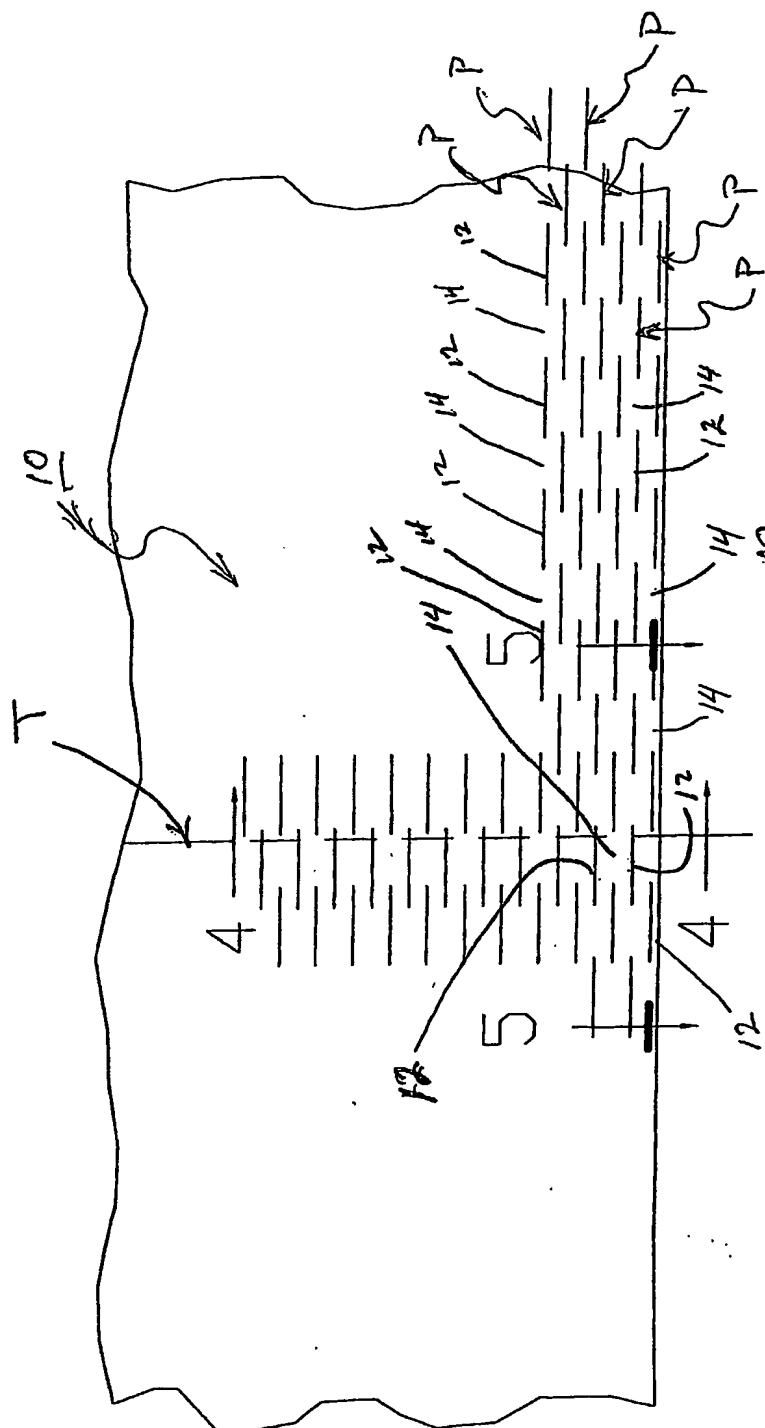
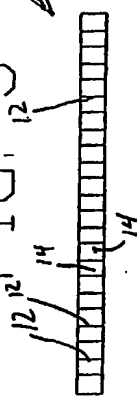
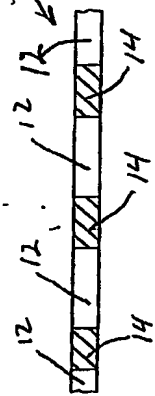


FIG. 3



451



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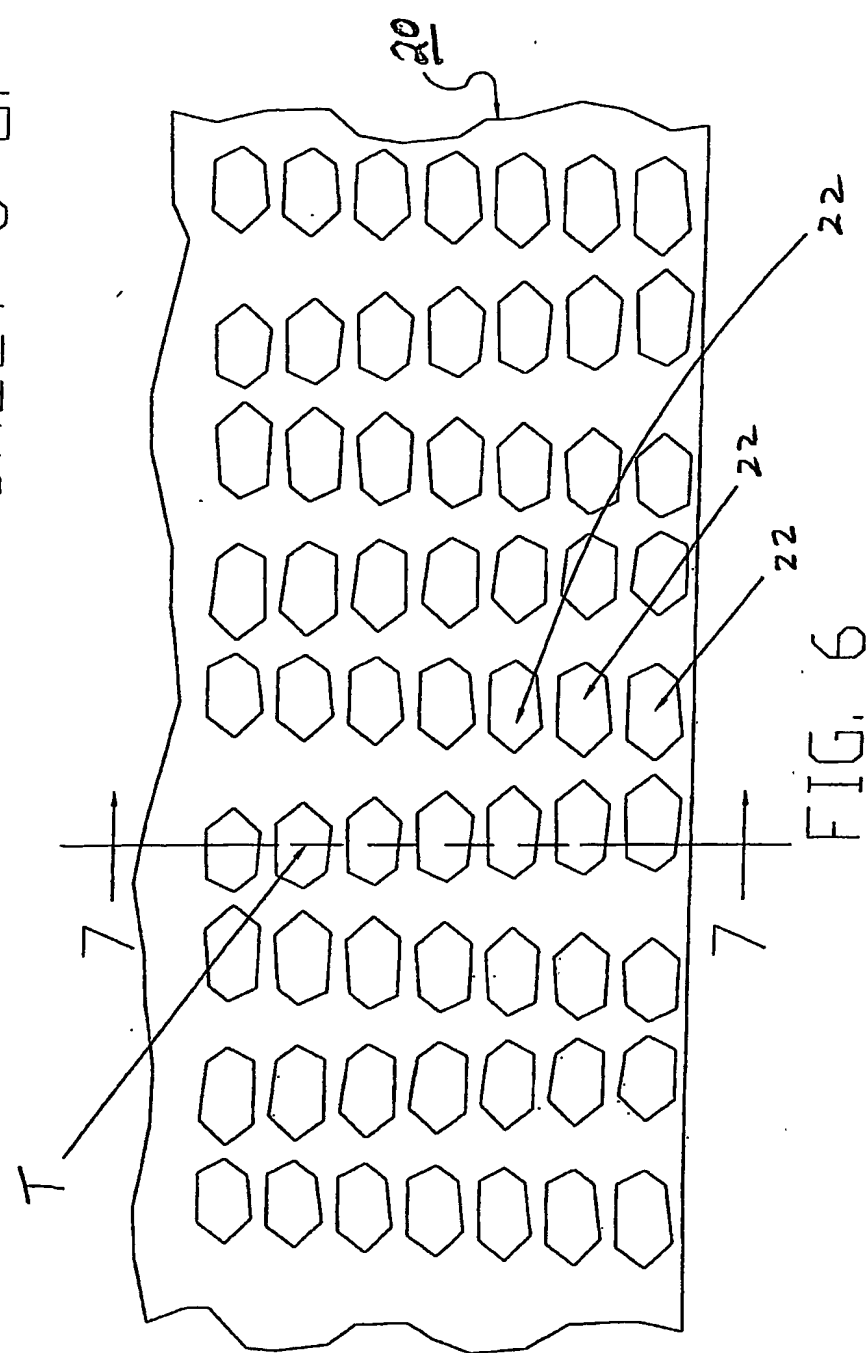


FIG. 6

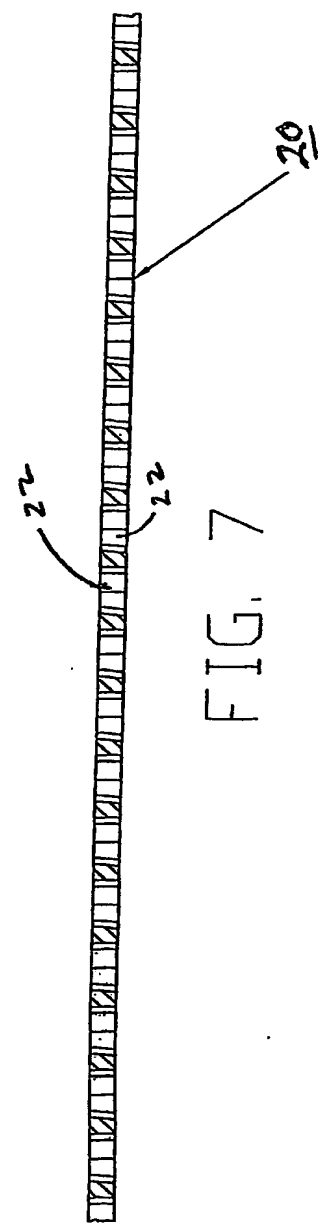


FIG. 7

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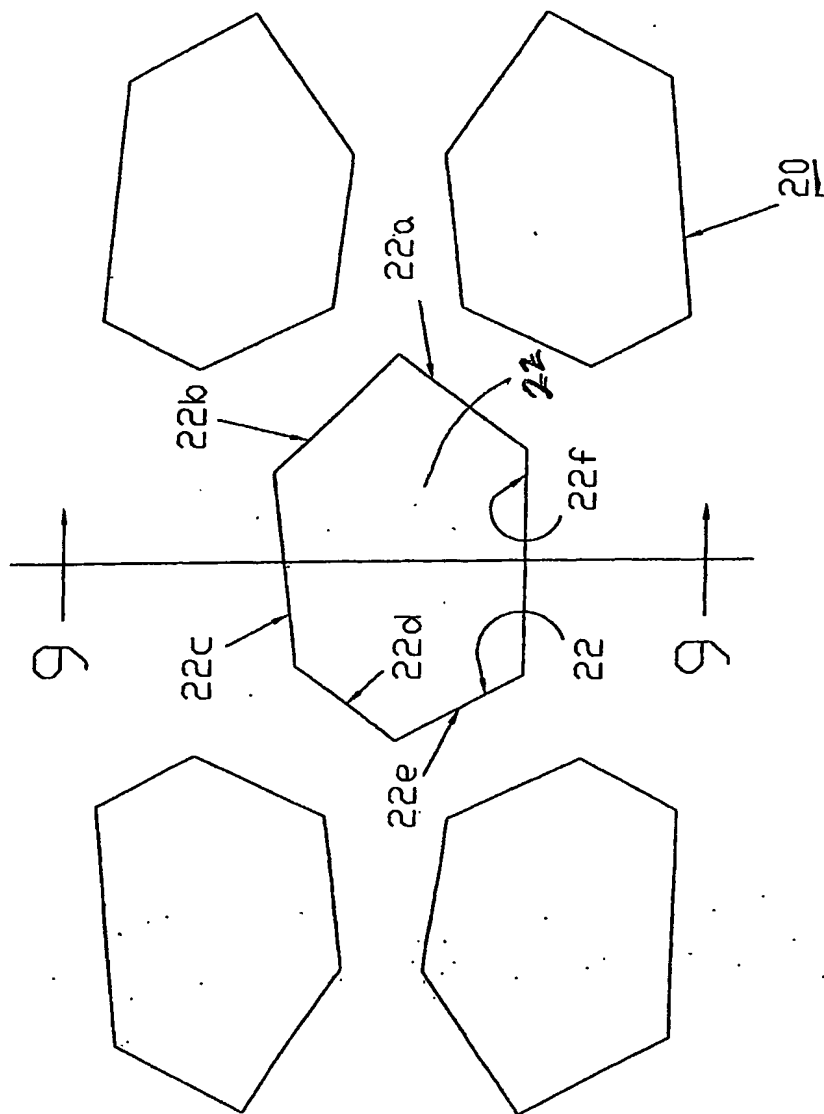


FIG. 8

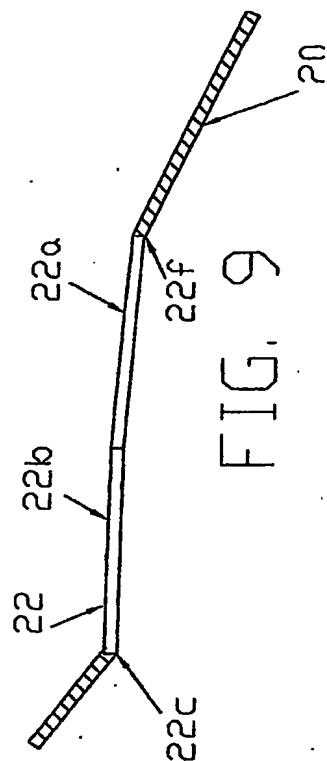


FIG. 9

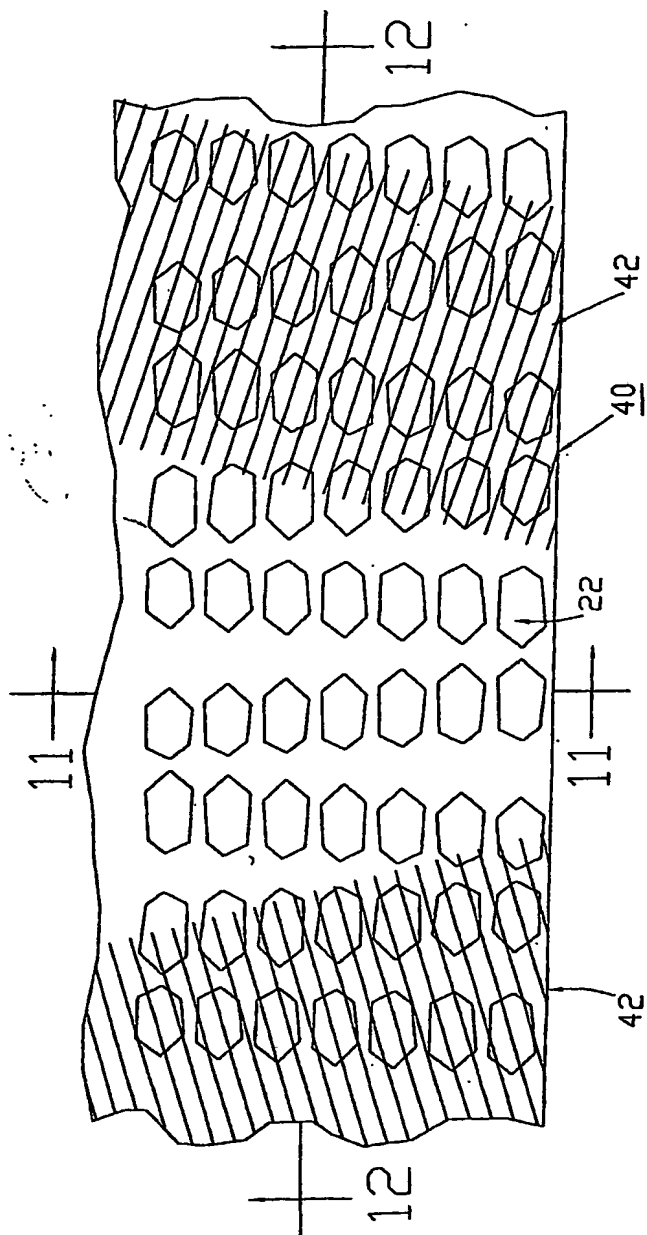


FIG. 10

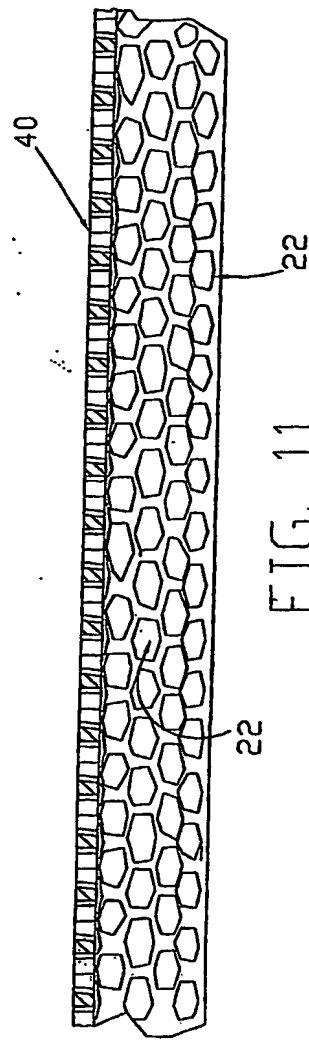


FIG. 11

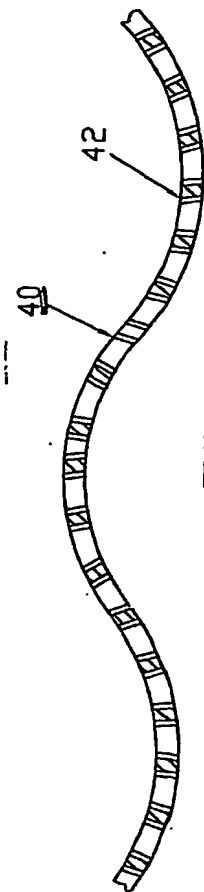


FIG. 12

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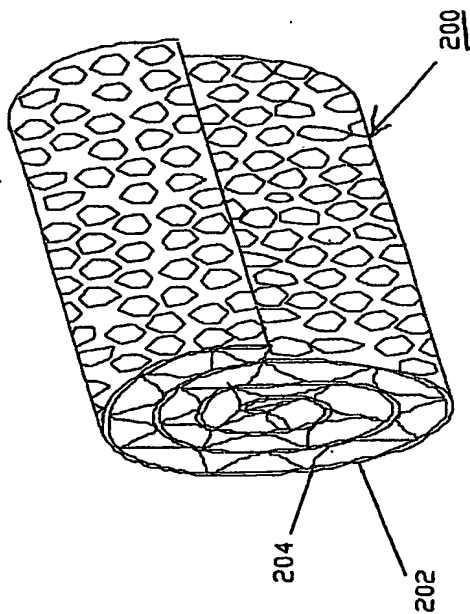


FIG. 13

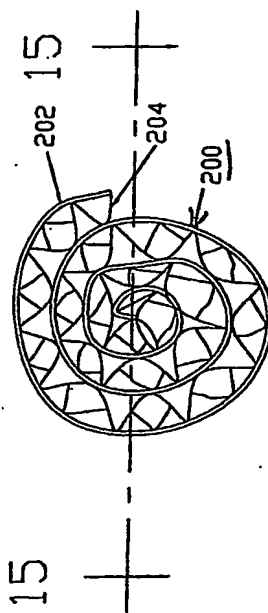


FIG. 14

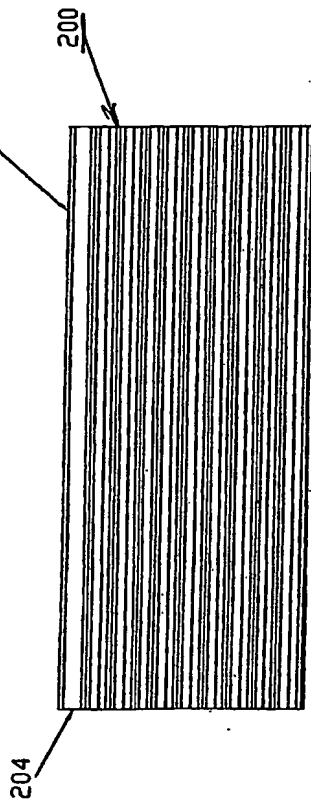


FIG. 15

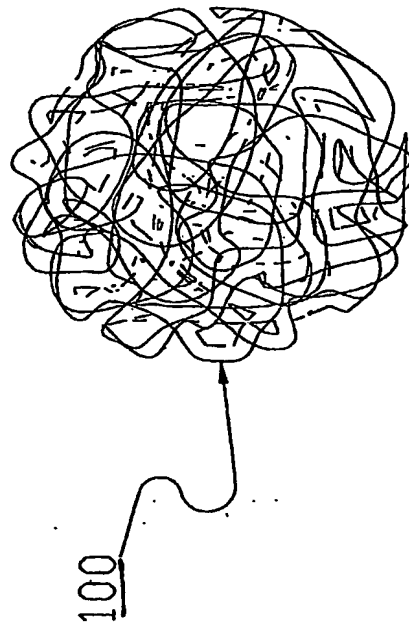


FIG. 16

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